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THE GREEN COLOR OF CERTAIN FERROUS MINERALS

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In two earlier papers[1] the writer has attempted to show that iron silicates exist in four important color modifications; i.e., colorless ferrous compounds, blue hydrous ferro-ferric compounds, gray or black anhydrous ferro-ferric compounds, and red and yellow ferric compounds. Both in the case of natural minerals and of artificial compounds it was shown that blues are apparently in all cases due to the presence of a hydrous double salt, both ferrous and ferric iron being present. Also evidence that iron greens are in reality mixtures of iron blues and iron yellows was presented. These different types of iron compounds are well represented in the mineral world and almost all minerals colored by iron may be fitted into one or another of the above groups.

The relative "ferrousness" of an iron-bearing substance may be expressed by means of its "ferro-ferric ratio," a numerical expression obtained by dividing the percentage content of ferrous oxide by the percentage content of ferric oxide. Materials high in "ic" iron therefore have a low ferro-ferric ratio, while for materials rich in "ous" iron this ratio is high. When the word "ratio" is used in the following discussion "ferro-ferric ratio" is to be understood.

During the course of the experimental work described in the earlier papers it was found that decided iron greens were developed only in such artificial compounds and mixtures as possessed comparatively low ratios. In other words, this color was found only in substances which were essentially ferric but which at the same time contained some ferrous iron. Thus greens developed in silicate mixtures only between ratios 0.60 and 0.70.

When these artificial compounds were compared with a series of green rocks and minerals some rather striking differences were found. In the natural minerals the average ratio was much greater than unity, in the artificial compounds much less than unity. The former are then chiefly ferrous, while the latter are predominately ferric. Although it appears that the majority of green rocks and minerals are distinctly ferrous, yet this is by no means always true, a fair number of ferric ones being evident.

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[1] *J. Elisha Mitchell Sci. Soc.*, **41**, 135 (1925), and *Am. J. Sc.*, **12**, 17 (1926).

In the ferric group we find such minerals as glauconite,[2] with a ratio of 0.082 (average of 6 analyses), serpentine[3] with a ratio of 0.759 (average of 5 analyses), dufrenite with a ratio of 0.076 (average of 3 analyses) two augites with an average ratio of 0.900 etc.

In the ferrous group we find such minerals as diopside with a ratio of 7.43 (average of 4 analyses), amphibole with a ratio of 4.21 (average of 5 analyses), two green biotites with an average ratio of 2.71, etc. The chlorites are almost entirely ferrous, having in very few cases ratios less than unity. Clinochlore[3] has a ratio of 2.57 (average of 7 analyses), prochlorite a ratio of 17.82 (average of 5 analyses), thuringite a ratio of 2.77 (average of 4 analyses), etc. Olivine is decidedly ferrous in character but enough nickel to affect its color is so often present that it seems best to omit this mineral from the discussion.

Among the non-igneous rocks are found one green sandstone with a ratio of 3.39, and thirteen green slates with an average ratio of 3.75. The green color of most, if not all, green slates seems to be due to chlorite,[4] the ratio being perhaps somewhat affected by other iron bearing minerals (such as hematite) also common in such rocks.

In making the artificial green compounds which were studied three different methods of procedure were employed; partial reduction of a ferric salt, partial oxidation of a ferrous salt, and direct precipitation from solutions containing ferric and ferrous salts which were not mutually reactive, but which would react with the precipitant to form a ferro-ferric salt. Under the conditions of the experiments the various compounds produced were either in solution or else were in the form of moisture laden colloidal or near colloidal precipitates, and under these conditions the production of mixtures containing ferric, ferrous, and ferro-ferric compounds proved impossible. However, mixtures of ferric and ferro-ferric and of ferrous and ferro-ferric compounds were obtained freely.

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[2] The analyses from which the following ratios were computed are taken chiefly from Dana's SYSTEM OF MINERALOGY, 6TH ED., and from *Bull.* **591,** *U.S.G.S.* The glauconite analyses are from Collet's LES DÉPÔTS MARINS, p. 165.

[3] One a typical analysis was omitted in computing the average.

[4] Renard, quoted by Dale in *Bull.* 275, *U.S.G.S.*, p. 12, lists the minerals found in green slates in the following order: quartz, muscovite, chlorite, hematite, and rutile. Since chlorite is the only green mineral reported it is apparently responsible for the green hue of the rock.

The solutions and colloidal precipitates could readily recombine to form new compounds so that should any ferric iron be present it would immediately unite with any ferrous iron also present to form a compound of the ferro-ferric type. If ferrous iron were in excess the final mixture would be composed of ferrous and ferro-ferric salts; if ferric iron were in excess a mixture of ferric and ferro-ferric salts would result, no mixture composed of more than two different types of compounds being obtained. Mixtures of a yellow ferric and a blue (hydrous) ferro-ferric compound of necessity would appear green and since in such mixtures ferric iron exceeds the ferrous iron the ratio is always low. The other type of mixture obtained—ferrous and ferro-ferric—consisted of a colorless ferrous and a blue (again hydrous) ferro-ferric salt and hence was always some shade of blue. Since ferrous iron predominates in such mixtures the ratio is always greater than unity.

If, during the growth of a mineral whether from a magma or from solution, both ferric and ferrous iron were present any iron silicate which might form would, just as in the case of the artificial compounds, consist either of a mixture of a ferro-ferric and a ferric or of a ferro-ferric and a ferrous salt, the type of mixture being dependent upon which type of iron was present in the greater amount. And as in the case of the artificial compounds, no green mineral with high ratio could form. Blue ferrous minerals might however be expected, and are in fact not at all rare. Among such minerals are vivianite, blue vesuvianite, iolite, crocidolite, glaucophane, blue calcite, and the like.[5] Green minerals of low ratio (rich in ferric iron) might likewise be expected under these conditions. Nevertheless many distinctly ferrous minerals are green in color, and it is the purpose of this paper to point out a possible origin of this phenomenon.

As is noted above, artificial green compounds were produced by a partial reduction of ferric salts and by a partial oxidation of ferrous salts as well as by direct precipitation. For example, partial oxidation of a blue ferro-ferric silicate causes the formation of a yellow ferric silicate and the mixture of the two, by the law of color mixture, gives a green hue to the substance. Partial oxidation of a colorless ferrous silicate first produces a blue ferro-ferric silicate and after further oxidation a yellow ferric silicate is also obtained. The mixture thus obtained contains blue ferro-ferric and yellow ferric silicates, and again appears green. In the same way the partial oxidation of a ferrous silicate mineral would produce blue and green colorations. But one difference between the behavior of the artificial compounds and of well crystallized minerals immediately appears. In the former, as has been pointed out, recombination easily takes place, so that ferric and ferrous compounds would not be stable in the presence of each other, and no green color could develop until almost, if not all, of the ferrous iron had entered into ferro-ferric compounds. In a solid crystal we find a different state of affairs. Here the constituent particles are held so firmly by the restrictions of the space lattice that much recombination without a simultaneous reorganization of the space lattice and consequent destruction of the original crystal could not take place. Although partial oxidation of a ferrous crystal could well transform certain of the iron atoms into the ferric state such ferric atoms could not change their positions as long as the original space lattice remained intact, and would not join their ferrous neighbors to form a ferro-ferric molecule. In this case all three types of iron compounds might exist side by side,—first, remnants of the original ferrous material, colorless and hence of no effect on the general color of the crystal;[6] second, blue ferro-ferric molecules; and third, yellow ferric molecules. Such a mixture would have a high ratio because of the ferrous iron it contained and at the same time would possess a decided green color due to the blue and yellow of the ferro-ferric and ferric molecules also present.

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[5] *Am. J. Sci.*, **12,** 19–20 (1926).

Since the color of iron compounds is very intense only an extremely small proportion of the iron need be in other than a ferrous condition for a noticeable color to develop. Hence only a slight degree of oxidation is called for. In a like manner a slight reduction of an originally ferric silicate might cause a green color to develop but, since dominantly ferric minerals can possess a green color even when directly precipitated from solution there is no point in following this particular phase of the problem further.

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[6] Colorless ferrous minerals are represented by some non-ferric vivianites and siderites. See Dana, 6th ed., pp. 277 and 815.

It is ordinarily considered that even such a mild oxidation or reduction as is here called for would cause a breaking down of the structure of the original crystal with a parallel development of "alteration products" and such is doubtless often the case. However, Winchell[7] has suggested on other grounds that such changes in the state of oxidation of the iron may sometimes take place without destruction of the crystal structure, his remarks applying specifically to chlorite. The experiments of Watson on partial oxidation of vivianite[8] also indicate such a possibility.

It is rather suggestive to note that the majority of green iron bearing minerals of high ratio are not those most common at great depths but rather those common at depths within the reach of atmospheric oxygen. Examples of such minerals are the chlorites, green vivianite, uralite and the like. Most of these minerals are in themselves "alteration products" and hence have passed through changes which might well include some slight degree of oxidation. On the contrary, the green iron-bearing minerals of low ratio are usually those which are formed in the greater depths or in other situations such that an increase in oxidizing conditions is not likely to occur after formation of the mineral. Among such deep-seated minerals are the green garnets, certain augites, etc. Glauconite appears to have formed directly from mixed solutions containing both ferrous and ferric iron with the latter present in greater amount, and hence resembles the artificial compounds in mode of origin. Dufrenite, often associated with glauconite, may well be of similar origin.

SUMMARY. It appears very probable that most green *ferric* minerals originated as such, although some may have suffered subsequent partial reduction, but that the green color possessed by certain *ferrous* minerals is a secondary development and is always caused by a partial oxidation of already crystallized material.

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[7] *Am. J. Sci.*, **11,** 283 (1926).

[8] *Am. Mineralogist,* **3,** 159 (1918).

ARGENTITE AND ACANTHITE

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Silver sulphide is found in nature in crystals which have been referred to the isometric system (argentite) and others which have been referred to the orthorhombic system (acanthite). The existence of acanthite as anything more than deformed argentite has been called in question by Krenner.[1] Argentite is commonly regarded as isomorphous with galena.[2] Recently Ramsdell[3] has shown that argentite and acanthite give identical X-ray patterns which are not isometric and he has concluded that they "do not represent distinct mineral species"; he has also argued that argentite can not be isomorphous with galena since it is not isometric. It is the object of this note to present additional evidence bearing on these points.

It is known[4] from studies of the thermal properties and electric conductivity of silver sulphide that the substance undergoes a reversible inversion[5] at about 180°C; this inversion takes place very easily and promptly on cooling as well as on heating. It is evident from the work of Ramsdell that the low temperature form of the substance is not isometric, and it is probable from crystallographic study of acanthite that the low temperature form is orthorhombic. The chief problem, then, is to determine the symmetry of the high temperature form of silver sulphide. The writers undertook to accomplish this task by means of X-ray patterns of the substance. Since silver sulphide changes in symmetry at about 180°C on both heating and cooling, no X-ray pattern obtained at ordinary temperature would give any information regarding the symmetry of the high temperature form, but a pattern obtained at any[6] temperature above 180°C would solve the problem, if it could be interpreted.

In order to obtain an X-ray pattern of silver sulphide at a temperature above 180°C the tiny glass tube containing the powdered substance was mounted between two strips of lead or lead glass which are opaque to X-rays. In a slot along the edge of each strip and close to the powdered mineral was placed a nichrome wire[7] for heating purposes. The tube was held in place and thermal insulation between the tube and the wire reduced by means of bakelite cement. A thermocouple was mounted at the end of the glass between the heating wires. The wires of the thermocouple were not exposed to the X-rays; and the heating wires were screened from these rays by the opaque lead or lead glass.

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[1] Dana: System of Mineralogy, p. 58, 1892.

[2] See the textbooks of Dana, Bayley, Rogers, Kraus and Hunt, etc.

[3] *Am. Mineral.*, X, 1925, p. 281.

[4] *Zeit. anorg. Chem.*, **CXVII**, p. 17, 1921.

[5] Urazov (*Min. Abst.* **II**, 1923, p. 154) reached the conclusion from thermal studies that silver sulphide is even tetramorphous.

[6] Assuming no inversion at a temperature above 180°C.

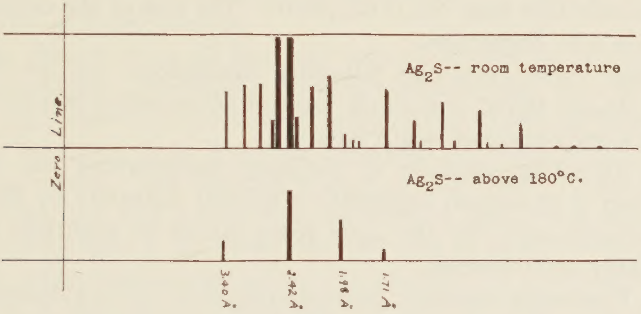

FIG. 1

Diagrams of X-ray patterns from powders of Ag_2S. Upper part taken below 180° C and lower part above 180° C. Width of lines proportional to width in photographs and length of lines proportional to intensity.

The X-ray patterns of silver sulphide at room temperature and also at 200–250° C are shown side by side in Fig. 1. The pattern at room temperature from argentite (and also from artificial silver sulphide) is complicated and, as reported by Ramsdell, is identical with that produced by acanthite. The X-ray pattern of silver sulphide above 180° C is simple and quite different from that produced at room temperature. This simple pattern, which consists of only four distinguishable lines, fits the chart of the pattern of crystals whose atoms are arranged in a body-centered cubic lattice.[8] On this basis the calculated specific gravity of the substance is 7.2, which checks well with the specific gravity of the argentite (7.2–7.36) as given by Dana. The four lines of the pattern also fit the chart of the patterns of crystals with simple cubic lattices, but the calculated specific gravity in this case is 10.4. The atomic weight of sulphur is small compared with that of silver so that reflections from planes of sulphur atoms may be too faint to be distinguishable. The stable form of silver sulphide above 180°C is therefore isometric and the lattice producing a visible X-ray pattern is body-centered; it seems probable that this lattice consists of silver atoms; the arrangement of the sulphur atoms has not been determined. The line on the pattern at 3.40 Ångstroms is the first order reflection from the (110) planes; the line at 2.42 Ångstroms is the second order reflection from the (100) planes; the line at 1.98 Ångstroms is the first order reflection from the (112) planes; and the line at 1.71 Ångstroms is the second order reflection from the (110) planes. The side of the elementary cube is 4.84 Ångstroms.

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[7] When using lead as a screen the wire was insulated by means of mica.

[8] W. P. Davey: *Gen. Elec. Rev.*, XXV, p. 565, 1922.

From these facts the following conclusions can be drawn:

1. Above 180°C the stable form of silver sulphide is isometric with a body-centered space lattice.
2. All silver sulphide at ordinary temperature—no matter whether it is natural argentite or natural acanthite or the artificial substance—has the same space lattice as acanthite and is probably orthorhombic.
3. Externally isometric natural crystals of silver sulphide were formed at temperatures[9] above 180°C, and at ordinary temperature are acanthite paramorphs after argentite.
4. Argentite and acanthite are both true and independent mineral species, though argentite exists as such only at temperatures above 180°C.
5. Above 180°C argentite and galena may be miscible to some extent in the crystal state since they are both isometric, but the miscibility is probably very limited not only because of the difference in the formulas, but also because argentite has a body-centered lattice while galena has the NaCl type of lattice, and finally because the length of the side of the unit cube of argentite (4.84 Ångstroms) differs decidedly from the same measure for galena[10] (5.93 Ångstroms). Therefore, according to present evidence argentite and galena should not be considered as isomorphous.

The authors take pleasure in acknowledging the helpful cooperation of Miss Emilie Hahn in the foregoing study of argentite and acanthite, which was made under the supervision of Professor A. N. Winchell.

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[9] Disregarding the influence of pressure and impurities upon the inversion temperature.

[10] L. S. Ramsdell: *op. cit.* p. 283.

EUXENITE-POLYCRASE FROM MATTAWAN TOWNSHIP, NIPISSING DISTRICT, ONTARIO

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The mineral here described occurs on lot 29, conc. 3, Mattawan township, about five miles west of the village of Mattawa, in a pegmatite dike which was opened up for feldspar during the winter of 1926 by M. J. O'Brien, Limited. The writer had seen the dike before mining began and is indebted to N. B. Davis of M. J. O'Brien, Limited, for specimens of the mineral and for the description of its occurrence.

The dike is 18 to 25 feet wide and is exposed for a length of about 300 feet, following a straight course a little west of north up a high hill which faces south to Lac Plein Chant, an expansion of the Mattawa river. The dike dips about 80° to the west, cutting syenite gneiss. The hanging wall is closely frozen to the gneiss while the foot wall is free from the country rock, being separated completely from it by about one-half inch of gouge consisting of rusty, scaly, decomposed micaceous material. In composition the dike is of the coarsely crystallized, segregated type. The middle portion is composed of crystals of microcline and massive white quartz; the quartz masses occurring sometimes in the middle with microcline on both sides, sometimes mostly on one side or the other. Along the sides next the wall rock there is a varying width of soda feldspar, up to two feet wide along the hanging wall, less along the foot wall. This is a common, typical arrangement in Ontario pegmatites and would probably be interpreted by most observers as indicating that the soda feldspar crystallized first, the microcline next and finally the quartz.

The chief euxenite occurrence is on the top of the hill 500–600 feet above the lake. It was first encountered within 6 feet of the surface. The euxenite is found in masses varying from pea size up to a diameter of 4-5 inches, principally in the microcline about 2 feet from the hanging wall, but now and than a mass may be found in the middle of the dike. While no definite crystals have been seen so far, the masses of euxenite have a tendency toward a tabular form tapering to sharp edges and may have some roughly formed crystal faces. The feldspar around the euxenite masses is colored red and is radially fractured, a characteristic effect of radioactive minerals in Canadian Precambrian rocks, as described by the writer in earlier publications[1] and more recently discussed in some detail by Walker and Parsons.[2]

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The pegmatite is compact and fresh looking with no evidence of weathering on the hanging wall side but there are slight indi-

Euxenite-polycrase from Mattawan township, Nipissing district, Ont.

	Per cent	Mol. Wt.	Bases	Acids
PbO	1.06	222	0.0048	
(Pb=0.98)				
UO_2	6.42	270.2	0.0234	
UO_3	0.43	286.2	0.0015	
(U=6.01=7.09 U_3O_8)				
ThO_2	0.97	264	0.0037	
(Th=0.85×0.38=0.32, U equivalent)				
(Ce, La, Di)$_2$O$_3$	0.20	330	0.0006	
(Yt, Er)$_2$O$_3$	28.07	258	0.1088	
(Atomic weight=105)				
FeO	0.29	72	0.0040	
Fe_2O_3	1.40	159.7	0.0088	
MnO	0.03	70.9	0.0004	
Al_2O_3	0.28	102.2	0.0027	
BeO		25.1		
CaO	1.08	56	0.0193	
MgO	0.05	40.3	0.0012	
ZrO_2	0.03	122.6		
SnO_2	0.09	150.7		
TiO_2	26.17	80.1		0.3267
Ta_2O_3	12.12	443		0.0273
Cb_2O_5	18.49	266.2		0.0694
SiO_2	0.03	60.3		
F	Not detected		0.1792	0.4234
$H_2O-110°$	0.04			
$H_2O+110°$	2.83	18	0.1572	
He	present—not determined			
Loss on ign	(2.99)			
	100.08			

Sp. Gr.=4.918 at 21.10°

$Cb_2O_5+Ta_2O_5 : TiO_2=1:3.3$

Pb/U+0.38 Th=0.155=1180 million years.

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[1] Geol. Survey, Summary Report, **1921**, Part D, pp. 57–58 D, 68D.
Geol. Survey, Summary Report, **1923**, Part C, p. 14C.
Am. J. Sci., Feb., **1925**, p. 139.

[2] Contributions to Canadian Mineralogy. **1923**, p. 25.

cations on the foot wall side near the seam of gouge. Minerals other than those mentioned are not prominent. No tourmaline and only a little black mica has been encountered.

The euxenite is black, unusually brilliant and fresh looking and seems to be quite unaltered by the normal weathering agencies. Hardness 6.5, cleavage none, fracture subconchoidal. Powder yellowish brown. Under the microscope brown and isotropic. It appeared to be exceptionally good material for Pb/U age determination. The pieces selected for analysis were examined under the microscope and appeared to be perfectly homogeneous and absolutely free from included impurities. An analysis yielded the results indicated above:

According to Lacroix[3] euxenite has $Nb_2O_5 : TiO_2 = 1 : 3$ or less while polycrase has $Nb_2O_5 : TiO_2 = 1 :$ 4 to 6. This mineral with $Nb_2O_5 + Ta_2O_5 : TiO_2 = 1 : 3.3$ is on the border line between euxenite and polycrase. This euxenite is noteworthy in that it yields age results in entire accord with those derived from the Ontario uraninites[4] while other complex U minerals of Ontario commonly give much lower figures. The very small amount of SiO_2 present, is, in the writer's opinion highly significant as indicating that this particular mineral has not suffered appreciable leaching, alteration or replacement by circulating waters, whereas those complex Ontario minerals which give low age figures invariably contain very appreciable amounts of silica, sometimes two percent or more. It is not likely that silica is an original constituent of such minerals and it seems probable that in cases where a mineral contains considerable silica (not due to inclusions of quartz, feldspar, etc.) it is present as a result of secondary replacement of some of the normal constituents, notably lead. Thus, if this theory is correct we have a method for judging the probable value of age results from the complex titano-tantalo-columbate minerals. If the mineral contains little or no silica we may attach considerable weight to the age result, if an appreciable amount of silica is present we can be almost certain that the age result is lower—often very much lower—than the true value. The writer hopes to present a more comprehensive discussion of this matter in a future paper.

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[3] MINÉRALOGIE DE MADAGASCAR, Vol. I, p. 386.

[4] Ellsworth: Radioactive Minerals as Geological Age Indicators, *Am. J. Sci.*, Feb., 1925, p. 143.

TODDITE—A NEW URANIUM MINERAL FROM SUDBURY DISTRICT, ONTARIO

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Within the last two or three years quite a number of pegmatite dikes in the Sudbury area have been more or less opened up in attempts to produce commercial feldspar. Certain of these efforts have met with fair success but in many cases the dikes appear to be not well adapted to the profitable extraction of feldspar. This area constitutes the present north western frontier of the feldspar mining industry in Canada and is particularly interesting because, aside from being more or less virgin ground for the occurrence of pegmatite minerals, the age of the rocks themselves is a subject of controversy. The older view, still held by many geologists is that they are identical in age with the supposedly pre-Huronian Laurentian-Grenville complex to the south east, while more recently Collins and Quirke have assigned them to the Huronian. The occurrence of uranium and thorium minerals in these rocks is therefore of special interest, leading us to hope that eventually their true age relationships may be accurately fixed by the radioactive disintegration method.

The mineral here described was found by the writer last summer in a pegmatite dike in the north west corner of lot 4, conc. 3, Dill township, Sudbury district. An opening had been made in the dike from which one carload of feldspar was shipped.

The dike is 30 to 40 feet wide and is exposed for a length of 100 feet cutting biotite-garnet-gneiss. It consists of the usual association of pale pink microcline in crystals not usually over one foot in diameter, white quartz, some badly cracked muscovite in thin plates and "books" up to 4 x 6 inches in diameter, a little decomposed biotite in very thin plates, a little smoky quartz, and a few garnets. There is little if any albite or other plagioclase feldspar visible. Columbite occurs sparingly in crystals and grains usually not over one quarter inch in diameter and is readily distinguished from the uranium minerals also present by the fact that it does not cause fracturing in the surrounding feldspar or quartz. Probably two or more different radioactive minerals occur. These do not exhibit definite crystal boundaries but usually take the form of small, rounded, elongated masses one to three inches in length, which cause well marked radial fracturing in the enclosing rock. For instance the mass of toddite, about $1\frac{1}{4}$ x $\frac{1}{2}$

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inch which furnished the material for the analysis, gave rise to fractures 5 inches long in the quartz and feldspar matrix. This specimen was selected for analysis because it appeared to be the least altered of the various individuals collected. Although there was an outer zone perhaps 1 to 2 millimeters thick next the matrix which by its duller lustre gave evidence of alteration, the inner portion was bright and lustrous and apparently very well preserved. On breaking up the mass after removing the outer altered material it appeared under the microscope to be perfectly uniform and homogeneous. The color is pitch-black, lustre submetallic, brilliant, fracture subconchoidal, very brittle. Cleavage none, hardness 6.5, powder brownish gray. The finely crushed powder is almost opaque under the microscope, even with arc light illumination, but very thin grains transmit some light, showing a dark brown color and isotropic character.

Analysis of the mineral yielded the following results:

	Percent	Mol. Wt.	Bases	Acids
PbO	0.44	222	0.0020	
(Pb=0.41)				
UO_2	8.71	270.2	0.0322	
UO_3	2.37	286.2	0.0083	
(U=9.65=11.38 U_3O_8)				
ThO_2	0.47	264	0.0018	
(Th=0.41×0.38=0.15 U equivalent)				
(Ce, La, Di)$_2O_3$	0.76	330	0.0023	
(Yt, Er)$_2O_3$	3.42	230	0.0149	
FeO	4.38	72	0.0608	
Fe_2O_3	4.68	159.7	0.0293	
MnO	2.62	70.9	0.0369	
Al_2O_3	0.04	102.2	0.0004	
BeO	0.47	25.1	0.0188	
CaO	2.02	56	0.0361	
MgO	0.22	40.3	0.0054	
ZrO_2	0.06	122.6		0.0005
SnO_2	0.53	150.7		0.0035
TiO_2	0.85	80.1		0.0106
Ta_2O_5	8.97	443		0.0202
Cb_2O_5	53.73	266.2		0.2018
SiO_2	1.77	60.3		0.0293
F	Not detected		0.2492	
H_2O−110°	0.35			0.2659
H_2O+110°	3.59	18	0.2000	
Hydrocarbons	Trace			
Loss on ignition	(3.42)			
	100.45			

Sp. Gr.=5.041 at 19.80°C.

Pb/U+0.38 Th=0.042=300 million years.

From the analysis it is evident that the mineral conforms in a general way to the columbite formula and may be considered as columbite in which some manganese and iron is replaced by uranium, which is present in sufficiently important amount to justify making it a new species.

The age of the mineral was determined as about 300 million years which is very much lower than that of the Ontario uraninites (1100–1200 million) but this result is not conclusive, as, in the writer's experience minerals of this sort often give very much lower age results than they should, due doubtless to the leaching or replacement of part of the lead.

That the material analyzed can be a mixture or intergrowth appears highly improbable. The microscopic examinations revealed no evidence of a lack of homogeneity. Nevertheless because of the opaque character of the mineral the possibility that it might be an intergrowth or mixture of columbite and uraninite was considered though no uraninite was found in the dike. If this were the case treatment with nitric acid would remove the uraninite, a test which was applied with negative results.

The name Toddite is proposed for this mineral in honor of E. W. Todd of the Ontario Department of Mines who has contributed so much to our knowledge of Canadian radioactive minerals.

NOTES ON THE MINERAL LOCALITIES OF RHODE ISLAND. I. PROVIDENCE COUNTY

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A recent survey of the minerals of the state of Rhode Island which are included in the museum collections of the Department of Geology of Brown University and of Roger Williams Park of Providence, together with a careful study in the field by the authors and others have revealed the presence of at least sixty species of minerals from forty-five localities. A brief discussion of the chief mineral localities and occurrences in Providence County[1] is here recorded.

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[1] A paper is being prepared by the authors on the remaining localities.

MINERALS FOUND

Actinolite
Albite
Allanite
Ankerite
Anthophyllite
Apatite
Aragonite
Arfvedsonite
Augite
Azurite
Barite
Beryl
Biotite
Boltonite
Bowenite
Calcite
Chalcopyrite
Crocidolite
Cryolite
Cyanite
Dolomite
Enstatite
Epidote
Fluorite
Galena
Garnet
Glaucophane
Gold[2]
Göthite
Graphite
Hematite
Hornblende
Hortonolite
Ilmenite
Ilvaite
Jamesonite
Knebelite
Limonite
Magnetite
Malachite
Melanterite
Microcline
Muscovite
Molybdenite
Octahedrite
Opal
Orthoclase
Ottrelite
Phlogopite
Pyrite
Pyrolusite
Pyrrhotite
Quartz
Rhodochrosite
Rhodonite
Riebeckite
Rutile
Scapolite
Scolecite
Serpentine
Siderite
Sphalerite
Talc
Titanite
Tourmaline
Tremolite
Zoisite

LOCALITIES

CRANSTON

Fenner's Ledge on Cranston street has been worked in the past for graphite and graphitic anthracite and shows quite a number of the minerals listed from Violet Hill, Manton Avenue. Large veins of fibrous quartz replacing actinolite traverse the exposure.

LOCALITY	MINERALS FOUND	REMARKS
Fenner's Ledge	Actinolite	With graphite.
	Graphite	Foliated, veined and bedded in shale.
	Hematite	Bright red in shale.
	Limonite	Yellow and iridescent.
	Melanterite[3]	Yellow and white, incrusting.
	Ottrelite[4]	Small lustrous plates in schist.
	Pyrite	In shale.
	Quartz	Massive, crystalline. Pseudomorphous after actinolite.
	Talc	With quartz in schist.

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[2] In chalcopyrite.

[3] Occurring with the melanterite but not directly in contact with it are two different iron sulphates, one almost pure white and the other of a cream color. Both show considerable amounts of ferric iron and magnesium is noted in the pure white one.

[4] A study of ottrelite, its crystallography, chemistry and origin is being made by the authors with Prof. C. W. Brown and will be presented in a later paper.

CUMBERLAND

Fully one-half of the minerals of Providence county are found within the limits of this township. Quartz, epidote and hematite are common while fluorite and galena are more or less abundant.

LOCALITY	MINERALS FOUND	REMARKS
Beacon Pole Hill	Arsenopyrite	Rare.
	Crocidolite	Blue, fibrous, with smoky quartz.
	Quartz	Smoky.
Copper Mine Hill	Actinolite	
	Azurite	Rare. Coatings on chalcopyrite.
	Chalcopyrite	Massive, with magnetite.
	Epidote	Veined.
	Hornblende	
	Magnetite	Massive, with cumberlandite.
	Malachite	Botryoidal, with chalcopyrite.
Cumberland Hill	Beryl	Green crystals, sparingly, with quarts.
Village -in quartz veins	Biotite	Small plates.
	Calcite	In glacial boulders with sphalerite, siderite and cryolite.
	Chalcopyrite	With galena and sphalerite.
	Chlorite	Altering to magnetite and ilmenite.
	Cryolite	Same as calcite.
	Cumberlandite	Massive.
	Epidote	Massive. Some large crystals.
	Fluorite	Octahedrons. Purple chlorophane.
	Galena	Cubes, octahedrons, some coated with pyrite, sphalerite, chalcopyrite and fluorite.
	Hematite	Fine crystals in veins in chlorite.
	Hornblende	Elongated crystals on quartz.
	Ilmenite	Lustrous plates in chlorite schist.
	Limonite	Coatings on quartz.
	Magnetite	Small octahedrons.
	Malachite	Botryoidal. Rare. On chalcopyrite.
	Molybdenite	In boulders with magnetite.
	Phlogopite	Crystals near contact with schist.
	Pyrite	Crystalline. Not common.
	Pyroxene	Augite crystals in quartz.
	Quartz	Rock crystal; Smoky; Milky; Massive; Ferruginous; Sagenitic, with hornblende and tourmaline; Prase.
	Siderite	In glacial boulders with calcite, etc.
	Sphalerite	"Black jack," crystalline, with chalcopyrite, fluorite and galena.

[6] Schorl in quartz at contact with gneiss, dichroite at contact with green schist.

LOCALITY	MINERALS FOUND	REMARKS
	Tourmaline[6]	Schorl in unterminated crystals, and dichroite, rare.
Diamond Hill	Barite	Rare.
	Hematite	
	Hornblende	
	Limonite	Coating quartz.
	Quartz	Var. Agate; Amethyst; Chalcedony; Chrysoprase; Heliotrope; Jasper; Milky; Onyx; Rock crystal; Sardonyx; Smoky.
	Zoisite	Dark crystalline with quartz.
Iron Mine Hill	Actinolite	
	Epidote	
	Hornblende	
	Hortonolite	Dark crystals.
	Ilvaite	In veins.
	Magnetite	Massive in cumberlandite boulders.
	Molybdenite	With magnetite.
	Pyrolusite	With iron ore and in gneiss.
	Serpentine	Greenish with iron ore.
	Talc	White and green foliated with iron ore.

LINCOLN

The Harris limestone quarries in this township are rather important because of the abundance of minerals found and these include the beautiful specimens of flattened, yellowish-tinged quartz.

LOCALITY	MINERALS FOUND	REMARKS
Harris Quarry	Calcite	Milky crystals, modified scalenohedrons and rhombohedrons; white calcite rhombs; Iceland spar. Limestone with graphite. Graphitic marble.
	Limonite	Black and brown.
	Opal	Blue coatings on weathered quartz.
	Quartz	Flat, tabular crystals, tinged with yellow in veins with calcite.
	Rutile	Minute brownish crystals in quartz.
	Scolecite	Minute crystals with calcite.
	Serpentine	Var. bowenite in limestone.
	Talc	White, pale green, foliated.

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[6] These cuts are located along the right of way of the Providence to Woonsocket Electric Railway chiefly between Miner's Crossing and Lime Rock Station (Wilbur Road).

LOCALITY	MINERALS FOUND	REMARKS
Trolley cuts[6]	Actinolite	In schist.
	Bowenite	With calcite.
	Calcite	Milky, good rhombs, in schist.
	Chalcopyrite	Massive in granite pegmatite.
	Göthite	From pyrite.
	Malachite	Botryoidal on chalcopyrite.
	Molybdenite	Rare. In granite.
	Muscovite	Rather large plates in granite.
	Octahedrite	White and pale pink crystals accompanying titanite.
	Orthoclase	Bright red, pink and rarely white in granite porphyry.
	Pyrite	In cubes in granite and schist.
	Quartz	Crystalline in veins; blue in contact.
	Rhodonite	Massive and crystalline in schist.
	Serpentine	With calcite in schist.
	Titanite	Black curved prisms in schist and granite.
	Tremolite	

JOHNSTON

Centredale Mineral Spring Ave.	Calcite	Rhombs, in green schist with epidote and quartz.
	Chalcopyrite	With epidote and quartz.
	Tremolite	White, fibrous.
Smith street—in green schist	Actinolite	
	Calcite	Rhombs, cream color.
	Chalcopyrite	Auriferous.
	Epidote	Massive and granular.
	Magnetite	Small octahedrons.
	Orthoclase	
	Pyrite	Massive.
	Quartz	Crystalline
One mile north	Jamesonite	Found in small amount in milky quartz dike in granite.

OCHEE SPRINGS

This is probably one of the best localities in the State to study the effects of contact mineralization and the gradation of iron-magnesium minerals to the more calcic varieties along the contact of the green schist and limestone. Huge masses of steatite are present and in this locality there are numerous pits and cavities in the masses from which the Indians fashioned pots and bowls.

MINERALS FOUND	REMARKS
Actinolite	Green, bladed in schist-limestone contact.

Minerals Found	Remarks
Ankerite	Brownish and black crystals in dolomite and limestone.
Anthophyllite	In clove brown crystals near contact.
Calcite	Small white crystals in the limestone.
Chlorite	In green schist.
Dolomite	Brownish with ankerite and siderite.
Hematite	Sparingly in black crystals.
Hornblende	Crystals in green schist.
Limonite	Pseudomorphs after pyrite.
Magnetite	With siderite.
Pyrite	Cubes, octahedrons, and pyritohedrons in steatite.
Siderite	In veins and pale brown crystals in dolomite.
Steatite	Gray massive.
Talc	Foliated, white and green in steatite.
Tremolite	White, bladed, in limestone-schist contact.

PROVIDENCE

Violet Hill Manton Avenue	Actinolite	Green, radiating.
	Ankerite	Rhombs in steatite.
	Apatite	Yellowish crystals in chlorite schist.
	Asbestus	White, in seams in schist.
	Boltonite	Sparingly in yellow crystals with talc.
	Calcite	Small crystals with talc and quartz.
	Chalcopyrite	Massive in limestone with malachite.
	Chlorite	In schist.
	Clinochlore	Small plates.
	Dolomite	Small transparent, colorless crystals in limestone.
	Enstatite	
	Epidote	Yellowish, elongated crystals with calcite in schist.
	Hematite	Black, lamellar, in limestone with chalcopyrite and malachite.
	Hornblende	Small black crystals.
	Limonite	Pseudomorphs after pyrite.
	Magnetite	Small octahedrons in amphibolite.
	Malachite	Botryoidal on chalcopyrite.
	Orthoclase	Pink with epidote.
	Pyrite	In cubes in limestone and schist.
	Pyroxene	Small crystals.
	Pyrrhotite	In small crystals in schist and steatite.
	Quartz	Chiefly as vein material.

Minerals Found	Remarks
Rhodochrosite	Same as rhodonite.
Rhodonite	Pink, with epidote and calcite.
Serpentine	Light and dark yellowish green with slickensided surfaces.
Steatite	Light gray.
Talc	White and pale green foliated with calcite.
Tremolite	White and fibrous.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, Oct. 7, 1926.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the President, Mr. Vaux, in the chair. Twenty-eight members and three visitors were present.

The following officers were elected for the year 1926–27:

President, George Vaux, Jr.
Vice-President, W. T. Clay,
Treasurer, Henry E. Millson
Secretary, F. A. Cajori
Councilor, H. W. Trudell

Mr. Vaux addressed the Society on the English and French mineral collections that he visited during the summer. The speaker described the famous Rashley collection of Cornwall minerals in which are unusual specimens of liroconite, cerussite and copper; the collection of economic minerals in the rooms of the Geological Society and the collection at the British Museum. The private collection of Mr. Arthur Russell of Reading contains a remarkable collection of minerals of the British Isles. The Natural History collection in Paris was likewise visited.

Mr. Cienkowski described a trip which he took during the summer to North Carolina. Attractive and large garnets were found in the mica mines in the vicinity of Spruce Pine and radio-active minerals, samarskite and gummite, were found in feldspar quarries also in this locality. Specimens of the minerals found on this trip were exhibited by the speaker.

Mr. Vaux exhibited several gems including cut morganite, kunzite and aquamarine from Madagascar.

F. A. Cajori, *secretary*

NOTES AND NEWS

ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA.

The seventh annual meeting of the Mineralogical Society of America will be held at the University of Wisconsin, Madison, Wisconsin, December 27–29, 1926, in conjunction with the Geological Society of America. The first session of the Mineralogical Society will be held at 2 P.M. on Monday, December 27.

It is earnestly requested that *everyone* secure a *certificate* when purchasing a ticket to Madison for if a minimum of 250 certificates is presented by those attending the combined meetings a half fare return rate will be granted. Even those not intending to use the certificates for their return are urged to comply with this request in order that the required number may be secured.

A *preliminary* list of papers to be presented at the seventh annual meeting will be found on the last page of this issue.

FRANK R. VAN HORN, *Secretary.*

The Hatch collection of fossils and minerals which formed a part of the exhibit of the mines and mineralogy section of the Centennial Exposition in 1876, has been presented to the University of Pennsylvania, following its purchase by George E. Nitzsche, recorder of the University.

Frederick A. Canfield's collection of minerals which was bequeathed to the U. S. National Museum has been appraised by Mr. Earl V. Shannon and transferred to Washington, D. C.

We learn that a series of boracite crystals, showing practically all the forms of the mineral recorded by Goldschmidt, are being offered for sale at moderate prices. Crystallographeres who may be interested should write to Baurat Eduard Schlöbcke, Vor dem Neuentor 3, Lüneburg, Germany.

Dr. Heinrich Baumhauer, professor of mineralogy at the University of Freiburg, Switzerland, died August 1, 1926, at the age of 78.

Announcement has been received of the sudden death on November 17 of the eminent geologist, Professer James Furman of Columbia University, at the age of 67.

CORRECTIONS TO VOLUME II.

No. 1, p. 19, 7th line from bottom, for "follow" read "follows".
p. 21, 4th line from bottom, for "Berolzeimer" read "Berolzheimer".
No. 2, p. 41, 10th line, for "Scheerer" read "Schairer".
p. 43, 3rd line, for "tealite" read "teallite".
p. 44, 3rd line under second mineral, for "Ploystein" read "Pleystein".
p. 44, 7th line from bottom, for "wenzelite" read "wentzelite".
No. 3, p. 47, 14th line, for "existant" read "existent".
p. 55, 8th line from bottom, for "bournite" read "bournonite".
p. 66, 21st line, for "O'Niell" read "O'Neill".
p. 71, 3rd line under Article IV, for "Geology" read "Geological".
p. 72, 12th line from bottom, for "penrosite" read "penroseite".
p. 76, 5th line from bottom, for "Naddack" read "Noddack".
No. 4, p. 107, 3rd line from bottom, for "Manganolangbeinete" read "Manganolangbeinite".
p. 108, 4th and 6th lines, for "analagous" read "analogous".
No. 5, p. 135, 1st line, for "75" read "75 cents".
p. 136, 3rd mineral, the name "ramsayite" should be in " ".
p. 136, 3rd and last line under ramsayite, for "Finland" read "Lapland".
No. 6, p. 168, 3rd line, for "Gannett" read "Garnett".
p. 168, the mineral names should be in " ".
p. 168, 2nd line from bottom, for "sklowdowskite" read "sklodowskite".
No. 7, p. 181, 18th line from bottom, for "Therefor" read "Therefore".
p. 184, 8th line, after "Fe_2SiO_4" insert "$-Mn_2SiO_4$" from the 10th line.
p. 185, 3rd line from bottom, for "anayles" read "analyses".
p. 193, 11th line, for "L.A." read "E.A."
p. 194, the two mineral names should be in " ".
No. 8, p. 199, 13th line, for "develpment" read "development".
p. 218, 7th line, for "abstracter" read "abstractor".
p. 219, 3rd line, for "wood, tin" read "wood-tin".
p. 219, 11th line from bottom, for "class 3" read "class 2".
No. 9, p. 250, 17th line, for O_2 read O_6.
p. 253, last line, for "Erisito" read "Ertesitö".
No. 10, p. 278, 6th line, for "Federov" read "Fedorov".
p. 278, 7th line, for "unites" read "units".

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PREPARED BY L. S. RAMSDELL

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